

RECORDS CONCERNING BIOLOGICAL CONTROL OF INSECT PESTS BY NEUROPTEROIDEA (INSECTA) IN NEW ZEALAND

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Abstract. This review, for the period 1890-1990, lists and discusses records concerning control of insect pests by neuropteroid predators in three parts: imported Raphidioptera (Snakeflies) and Neuroptera (Lacewings); non-endemic Neuroptera; endemic Neuroptera. All of many purposeful importations of neuropteroid predators to New Zealand from the 1890s to the 1970s were unsuccessful and were discontinued. The emphasis has changed to observations on self-introduced or accidentally introduced species, particularly three from Australia and one from Europe.

A possible effect of non-specific predators is the loss of native insect species in the groups they attack. Two instances indicate that established introduced species could affect native species. Concerning the endemic insect fauna, both imported and introduced predators could be considered as pests.

Information on members of the Superorder Neuropteroidea as predators of insect pests is reviewed. Of the three Orders accepted for the Superorder, Raphidioptera (Snakeflies) do not occur naturally in New Zealand, Neuroptera (Lacewings) are the main group considered here and Megaloptera (aquatic Alderflies, Dobsonflies) are not involved.

This review covers references in the period 1890-1990 and is in three parts. Not all references to lacewings as predators, amongst the multitude of papers dealing with insect pests, may have been found but it is believed that most are included and certainly sufficient to illustrate what has happened during a century.

I. LIST OF IMPORTED NEUROPTEROIDS

This is a list of references to importations of Neuropteroidea, namely Raphidioptera and Neuroptera, into New Zealand for insect pest control. Complementary to records compiled by the author, results of biological control work done at Cawthron Institute, Nelson, from 1921 (Gourlay 1930) and in a series of symposium papers by Miller, Clark & Dumbleton (1936) have been useful sources. More recently, a booklet on imported invertebrates (Cameron *et al.* 1987) and a book on biological control (Cameron *et al.* 1989) have been especially useful references, particularly as they include information from Department of Scientific and Industrial Research files (which contain the Cawthron Institute biological control records). However, in the latest publication above, the information is separated according to host insects in different chapters by different authors (Thomas 1989, on Aphids; Charles 1989, on Mealybugs; Zondag & Nuttall 1989, on Pine Adelgid; and others). The present list presents the Neuroptera references together and includes other records and further information.

The genera and species imported are listed and the insects they are recorded as being brought in to control are given in square brackets on the same line. References to the

importation of each are listed underneath, and at the end of each reference the source country and the year of importation (where known) are given in square brackets, so that the reason for grouping the references under a particular name can easily be seen.

The list contains both named and unnamed species which have been imported to control introduced insect pests. The imported species are listed using present-day nomenclature, which is particularly noticeable in the Chrysopidae and the revised list for this family by Brooks & Barnard (1990) is followed, as is the update for the genus *Chrysoperla* by Brooks (1994).

The pest insects are given both as particular species and as groups, as follows.

Aphids. Hemiptera: Homoptera: Aphididae

A large number of introduced species are mainly pests on crops, vegetables, fruit trees and garden flower plants. The Spruce Aphid, *Elatobium abietinum* (Walker, 1849) is a pest of introduced spruce trees.

Codling Moth. Lepidoptera: Tortricidae: *Cydia pomonella* Linnaeus, 1759

Codling Moth (or Codlin Moth) is a pest of apples.

Grass Grub. Coleoptera: Scarabaeidae: Melolonthinae: *Costelytra zealandica* (White, 1846)

Grass Grub is a pasture pest and also attacks many other plants including roots of trees.

Mealybugs. Hemiptera: Homoptera: Pseudococcidae

Many introduced and endemic species are pests on a wide range of plants especially fruit trees, grape-vines and ornamental plants.

Passion Vine Hopper. Hemiptera: Homoptera: Ricaniidae: *Scolypopa australis* (Walker, 1851)

The Passion Vine Hopper is very common in New Zealand and is recorded as a pest of passion fruit vines, kiwi fruit and ornamentals by Hill & Steven (1989).

Pine Adelgid. Hemiptera: Homoptera: Adelgidae: *Pineus laevis* (Maskell, 1885).

The Pine Adelgid (also known as Pine Twig Chermes and Pine Woolly Aphid) is a pest of introduced pine. Miller & Clark (1935) recorded this species as *Pineus (Chermes) pini* and noted "*Pineus pini* is often popularly known as the "White blight" of pine trees...". "Pine Adelgid" was used by Cameron et al (1987: 16). Synonymy for this species was listed by Wise (1977).

Order RAPHIDIOPTERA

This Order does not occur naturally in New Zealand.

Family RAPHIDIIDAE

Raphidia sp.

[Codling Moth]

- Raphidia* sp.: Wight, 1890 (June), N.Z. Farmer 10: 206. [U.S.A.].
Raphidia sp.: Riley & Howard, 1890, Insect life 3(2): 43. [U.S.A.].
Raphidia : Wight, 1891 (February), N.Z. Farmer 11: 52.
Raphidia : Wight, 1891 (April), N.Z. Farmer 11: 140. [1890].
Raphidia sp.: Anon., 1891 (October), N.Z. Farmer 11: 414. [U.S.A., 1891].
Raphidia sp.: Riley & Howard, 1892 (June), Insect life 4(9,10): 339. [U.S.A.].
Raphidia sp.: Clausen, 1962, Entomophagous insects, 594. [U.S.A., 1890].
Raphidia sp.: Cameron *et al.*, 1987, DSIR Bull. No. 242: 22. [U.S.A., 1890].

Wight (1890 June) recorded that *Raphidia* specimens were then received in New Zealand. Riley & Howard (1890 Sept.) recorded that *Raphidia* had been collected and sent to New Zealand for Codling Moth control, and had arrived safely according to Wight (1890). Wight (1891a, b) recorded that Mr Koebele [of North America] sent specimens of *Raphidia*, and in the second article stated that they were sent "Last April...", presumably April, 1890. Wight (1891c) stated that he had sent *Raphidia* specimens from Auckland to Australia but no date is given. An unsigned article (Anonymous 1891) fully recorded a second visit by Koebele in 1891 and the release of predators; a figure of a *Raphidia* larva was included. Riley & Howard (1892) mentioned attempts to introduce *Raphidia* specimens carried from U.S.A. to New Zealand as recorded by Anon. (1891).

The above records indicate an introduction of *Raphidia* sp. from U.S.A. by June 1890 and another by October 1891. Clausen (1962) and Cameron *et al.* (1987) noted only the 1890 introduction.

Order NEUROPTERA

Family CONIOPTERYGIDAE

Conwentzia psociformis (Curtis, 1834)

[Aphids]

- Conwentzia psociformis* : Dumbleton, 1936, N.Z. J. Sci. Tech. 18 (7): 590. [1924].
Conwentzia psociformis : Clausen, 1962, Entomophagous insects, 606. [England, 1924].
Conwentzia psociformis : Cameron *et al.*, 1987, DSIR Bull. No. 242: 14. [England, 1924].
Conwentzia psociformis : Thomas, 1989, CAB Tech. Comm. No. 10: 61 (Table 11.1), 63. [North America, 1924].

Kimmins & Wise (1962) noted this species as introduced and not established, but Meinander (1972, 1990) recorded it in New Zealand. Dumbleton (1936) had stated that the species was not known to have established. Thomas (1989) noted that *Conwentzia psociformis* had been sent from North America by A. Koebele in 1924, but this species was originally European. Meinander (1972) recorded it as first intercepted in U.S.A. from European specimens in 1954. Consequently the validity of named sources or species for the 1924 specimens is in question.

Family HEMEROBIIDAE

Sympherobius barberi (Banks, 1903)

[Aphids, Mealybugs]

- Sympherobius barberi* : Dumbleton, 1936, N.Z. J. Sci. Tech. 18 (7): 589.

Sympherobius barberi : Cameron *et al.*, 1987, DSIR Bull. No. 242: 14, 17. [? U.S.A.].

Sympheriobius barberi : Thomas, 1989, CAB Tech. Comm. No.10: 61 (Table 11.1), [error for *Sympherobius*]. [? N. America].

Sympherobius barberi : Thomas, 1989, CAB Tech. Comm. No.10: 63. [? U.S.A.].

Sympherobius barberi : Charles, 1989, CAB Tech. Comm. No.10: 232 (Table 39.4) [Chrysopidae in error]. [U.S.A., 1925].

Sympherobius californicus Banks, 1911

[Aphids, Mealybugs]

Sympherobius californicus : Dumbleton, 1936, N.Z. J. Sci. Tech. 18 (7): 589.

Sympherobius californicus : Cameron *et al.*, 1987, DSIR Bull. No. 242:14, 17. [? U.S.A.].

Sympheriobius californicus : Thomas, 1989, CAB Tech. Comm. No.10: 61 (Table 11.1) [in error for *Sympherobius*]. [? N. America].

Sympherobius californicus : Thomas, 1989, CAB Tech. Comm. No.10: 63. [? U.S.A.].

Sympherobius californicus : Charles, 1989, CAB Tech. Comm. No.10: 232 (Table 39.4) [Chrysopidae in error]. [U.S.A., 1925].

Sympherobius sp.

[Mealybugs]

Sympherobius sp.: Charles, 1989, CAB Tech. Comm. No.10: 232 (Table 39.4). [U.S.A., 1925, 1926].

Hemerobius stigma Stephens, 1836

[Pine Adelgid]

Hemerobius stigma : Miller & Clark, 1935, N.Z. J. Sci. Tech. 16: 305-306. [England].

Hemerobius stigma : Clausen, 1978, U.S. Dep. Agric., Agric. Handb.No. 480: 50. [England, 1932].

Hemerobius stigma : Cameron *et al.*, 1987, DSIR Bull. No. 242: 16. [England, 1932].

Hemerobius stigma : Zondag & Nuttall, 1989, CAB Tech. Comm. No.10: 296. [U.K., 1932].

Clausen (1962) mentioned *Hemerobius* introduced into New Zealand for control of Chermidae (now Adelgidae) attacking forest trees.

Family CHRYSOPIDAE

U.S.A., Europe - before 1904

Chrysopa sp.

[Aphids]

Chrysopa sp.: Anon., 1891, (October), N.Z. Farmer 11: 414. [U.S.A., 1891].

In an unsigned article (Anonymous 1891) it is recorded that Mr Koebele brought some specimens, of a *Chrysopa* useful against Aphids, on his then recent second visit to New Zealand.

Charles (1989: 231) accepted a record by Broun (1898) for *Chrysopa* sp. feeding on Mealybugs, even though it was seven years after a possible introduction of Chrysopids by Koebele in 1891 (Anonymous 1891). Broun actually referred to a figure of *Chrysopa* provided earlier by Kirk (1895: 158 [not 198]), which appears to be the source of Broun's use of "*Chrysopa*", but Kirk's figures were from a Californian publication and not intended as a record of importation. Broun recorded larvae of lace-winged flies feeding on Aphids, and adults feeding on Mealybugs. Wise (1993) did not accept Broun's *Chrysopa* but took his species to be *Micromus tasmaniae* which is the common Lacewing in New Zealand and is an active aphid predator. Further consideration on Broun's mealybug predator may be required but it is not likely to have been a species of Chrysopidae.

Chrysopa perla Linnaeus, 1758

[? Aphids]

Chrysopa perla Schneider: Hutton, 1904, Index faunae Novae Zealandiae, 354. [Europe].

In a "List of Naturalised Animals", Hutton included this species, as introduced from Europe. The list was made up of "... animals introduced, either intentionally or unintentionally, by human agencies, and have become so well established that they may be considered as part of the fauna.", (Hutton 1904: 347). The species name had been received (Hutton Preface iii, iv) in a general list from F. W. Hilgendorf, who was Lecturer in Biology (from 1899), Canterbury Agricultural College at Lincoln, Canterbury, in the South Island of New Zealand. As introduced Chrysopids have never become established in this country the species may have been the common Hemerobiid *Micromus tasmaniae*. It is tempting to suggest that it was the European Hemerobiid *Wesmaelius subnebulosus*, which is now one of the three species predatory on Aphids on crops on the Canterbury Plains. However, the earliest collection of *W. subnebulosus*, known to the present author, is 1920 (see below, Part II).

U.S.A., Canada, Pakistan - 1922-1972

Chrysopa oculata Say, 1849

[Aphids]

Chrysoperla oculata: Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1), 61. [U.S.A., 1925, 1926].

This must be one of the two *Chrysopa* species referred to by Clausen (1978: 50) as imported from North America in 1926 for aphid control.

Chrysopa sp.

[Aphids, Pine Adelgid]

Chrysopa sp.: Gourlay, [1926], N.Z. State For. Serv. News Letter, 13-17. [Canada, 1925].

Chrysopa sp. 2: Thomas, 1989, CAB Tech. Comm. No. 10: 60 (Table 11.1), 62. [Canada, 1925, 1927].

Gourlay ([1926]) described the introduction of 1910 *Chrysopa* sp. specimens from Canada, with the assistance of A. Gibson, Dept. of Agriculture, Victoria, British Columbia, which arrived in New Zealand on 7 December 1925 and in Nelson on 9 December. Some were released immediately in Nelson, others sent to control Aphids on oak trees in Christchurch and others retained for breeding. Rearing was done successfully on Aphids in general and, also, on "Pine aphid" and "Spruce aphid", until the following February. Gourlay's article must have been completed in 1926 [not 1925 as listed (Miller 1956)]. A comment by Gourlay, that the species overwintered under the bark of forest trees, suggests that this may have been the species later described as *Chrysopa downesi* by Smith (1932) [see below]. Tillyard (1926b:12) recorded that 1900 hibernating adults of an undetermined Canadian species of Chrysopidae had been received for the control of Aphids in general with the aid of A. Gibson and W. Downes. This must be the *Chrysopa* sp. 2 of Thomas (1989) received in 1925. Thomas also recorded a second lot received in 1927.

Clausen (1962) mentioned *Chrysopa* spp. introduced into New Zealand for control of Aphids and Chermids on pine, which may include this entity. Zondag & Nuttall (1989: 296) stated that there is no record by New Zealand authors of an importation of two species of *Chrysopa* [for control of *Pineus laevis*] from North America in 1926, as reported by Clausen (1978) in a section on "Pine Aphid". However, *Chrysoperla plorabunda* and *Chrysopa oculata* were both imported from the U.S.A. that year for aphid control and obviously Clausen was referring to those.

Chrysopa nigricornis Burmeister, 1839

[Aphids]

Chrysopa nigricornis : Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1), 62. [U.S.A., 1972].

Chrysoperla plorabunda (Fitch, 1855)

[Aphids]

Chrysopa carnea : Valentine, 1975, Proc. 28th N.Z. Weed & Pest Control Conf., 195. [U.S.A.].

Chrysopa carnea : Thomas, 1977, Proc. 30th N.Z. Weed & Pest Control Conf., 182.

Chrysoperla carnea : Cameron *et al.*, 1987, DSIR Bull. No. 242: 14. [U.S.A., 1968, 1970].

Chrysoperla plorabunda : Cameron *et al.*, 1987, DSIR Bull. No. 242: 14. [U.S.A., 1925].

Chrysoperla plorabunda : Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1), 61. [U.S.A., 1922, 1925, 1926].

Chrysoperla carnea : Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1), 62. [U.S.A., 1968, 1970].

Gourlay (1930: 9) had listed importations of *Chrysopa* spp. against Aphids between 1921 and 1929, Dumbleton (1936: 590) recorded *Chrysopa* spp. imported from North America for aphid control from 1922 onwards, and Cameron *et al.* (1987: 14) recorded the same for 1922, but there is no record of any species other than *plorabunda* for that year.

Valentine (1975) recorded that *Chrysopa carnea*, from U.S.A., had not established but suggested a different strain may have a better chance. Thomas (1977) listed *Chrysopa carnea* as one of the insect species introduced against Aphids in the 1968-1976 period.

This must be one of the two *Chrysopa* species referred to by Clausen (1978: 50) as imported from North America in 1926 for aphid control.

Charles (1989: 231) noted *californica* Coquillett, 1890 as a synonym and made reference to it (1989: 233), but there is no indication that specimens were introduced under that name. Brooks (1994) confirmed the synonymy with *Chrysoperla plorabunda*.

Brooks (1994) has placed specimens from North America (Nearctic) in *Chrysoperla plorabunda*, so previous records of *C. carnea* from U.S.A. are now included here.

Chrysoperla downesi (Smith, 1932)

[Pine Adelgid]

Chrysopa downesi Smith, 1932, Ann. Ent. Soc. America 25: 591-595.[Canada, 1927].

Chrysopa sp. (3): Thomas, 1989, CAB Tech. Comm. No. 10: 60 (Table 11.1), 62. [Canada, 1927].

Smith (1932) described this new species, noted it was the species introduced into New Zealand and mentioned that Mr Downes had advised that this species overwintered as adults under the loose bark of pine trees. It is consequently here taken to be the *Chrysopa* sp. 3 of Thomas (1989). This species of *Chrysopa* spp. was received from Downes in October 1927 and subsequently released as next generation larvae onto pine trees amongst Pine Adelgid populations, presumably in March, April, May 1928 (not 1927). This entity is confirmed as a separate species in *Chrysoperla* by Brooks (1994).

Chrysoperla carnea (Stephens, 1836)

[Aphids]

Chrysoperla carnea : Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1), 62. [Pakistan, 1969].

Thomas (1977) listed *Chrysopa carnea* as one of the insect species introduced against Aphids in the 1968-1976 period.

Brooks (1994) has retained specimens from Europe to China (Palearctic) as *Chrysoperla carnea*, which is followed here, although another species is recorded from Pakistan.

*Australia - 1921-1969***Chrysopa** sp.**[Aphids]**

Chrysopa sp. (1) : Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1), 61. [Australia, 1921].

There is no indication as to whether this is the same as the following 1921 importation or not. Thomas (1989) thought this was the first introduction of Chrysopids. Gourlay (1930: 9) had listed *Chrysopa* spp. as imported against Aphids between 1921 and 1929.

Chrysopa sp.**[Mealybugs]**

Chrysopa sp. : Charles, 1989, CAB Tech. Comm. No.10: 231. [Australia, 1921].

Charles' suggestion (1989: 230), that *Chrysopa* spp. imported from Australia for mealybug control were *C. ramburi*, possibly includes this importation, but it is not known if it is the same species or importation as Thomas (1989) recorded for Aphids.

Chrysopa sp.**[Mealybugs]**

Chrysopa sp. : Charles 1989, CAB Tech. Comm. No.10: 230 (Text + Table 39.3). [Australia, 1928].

The suggestion by Charles (1989: 230), that *Chrysopa* spp. imported from Australia for mealybug control were *C. ramburi*, would possibly include this importation.

Plesiochrysa ramburi (Schneider, 1851)**[Aphids, Mealybugs]**

Chrysopa ramburi : Dumbleton, 1936, N.Z. J. Sci. Tech. 18 (7): 589.

Chrysopa ramburi : Cameron *et al.*, 1987, DSIR Bull. No. 242: 17. [? Australia].

Chrysopa ramburi : Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1), 62. [U.S.A., 1928].

Chrysopa ramburi : Charles, 1989, CAB Tech. Comm. No.10: 230 (Table 39.3 + text), 231. [U.S.A. ex Australia, 1928].

Charles (1989: 230) intimated that all shipments of *Chrysopa* spp. from Australia for mealybug control were *C. ramburi*. Clausen (1962) mentioned *Chrysopa* spp. introduced into New Zealand for control of aphid and mealybug pests, which may include this species.

Chrysopa sp.**[Passion Vine Hopper]**

Chrysopa sp. : Cameron *et al.*, 1987, DSIR Bull. No. 242: 17. [Australia, 1965].

Hill & Steven (1989: 242) described the introduction of a chrysopid species from Australia and subsequent releases of larvae and adults, based on the work and results of R. A. Cumber.

Chrysopa spp.**[Aphids]**

Chrysopa sp. : Cameron *et al.*, 1987, DSIR Bull. No. 242:14. [Australia, 1969].

Chrysopa spp. (4, 5, 6) : Thomas, 1989, CAB Tech. Comm. No.10: 60 (Table 11.1). [Australia, 1969].

Chrysopa spp. : Thomas, 1989, CAB Tech. Comm. No.10: 62. [Australia, 1969].

Family ITHONIDAE

Ithone fusca Newman, 1838**[Grass Grub]***Ithone fusca* : Tillyard, [1926], Proc. Pan-Pacific Sci. Congr. Australia, 1923 1: 389. [Australia].*Ithone fusca* : Miller, 1936, N.Z. J. Sci. Tech. 18 (7): 592. [Australia, 1921-22].*Ithone fusca* : Dumbleton, 1942, N.Z. J. Sci. Tech. (A) 23 (6): 311. [Australia, 1921].*Ithone fusca* : Cameron *et al.*, 1987, DSIR Bull. No. 242: 7. [Australia, 1921].*Ithone fusca* : Cameron & Wigley, 1989, CAB Tech. Comm. No.10: 11. [Australia].

This species was earlier thought to be a predator on other soil fauna (Tillyard [1926]) but this idea has since been discredited (New 1986). Tillyard noted the failure of this species to acclimatise and Miller (1936) recorded the introduction as unsuccessful.

RESULTS

The importations recorded above are summarised in Table 1. All the records show that not one of the purposefully imported species of Raphidioptera and Neuroptera has been established in New Zealand, despite many attempts during more than 80 years. As recorded by various authors in Cameron *et al.* (1989), specimens were sometimes dead on arrival or were never released but, in other cases, species released were never recovered after the season of liberation.

II. INDIGENOUS NEUROPTERA IN NEW ZEALAND

Non-endemic species of New Zealand Neuroptera are listed and references given for information on control of insect pests. Pests are as in Part I except for the following.

Aphids.

The Aphids group here includes *Eriosoma lanigerum* (Hausmann, 1802), Family Pemphigidae, a pest of apple trees, which is still commonly known as the Woolly Apple Aphid.

Mites. Acarina: Tetranychidae

Phytophagous mite pests in orchards have been recorded as hosts.

Pittosporum Triozid. Hemiptera: Homoptera: Triozidae: *Trioza vitreoradiata* (Maskell, 1879)

This is included here as it can be a pest on New Zealand ornamental and hedge *Pittosporum* species, and represents a different host group from the others. Synonymy was listed by Wise (1977), but Family status has since been accepted for the previous Subfamily. The species has been commonly known as the Pittosporum Psyllid. One of the true Psyllids, *Psylla albizziae* (Ferris & Klyver, 1932), Family Psyllidae, has also been recorded as a host.

Table 1. Summary of importations of neuropteroid predators.

Year	Source	Species	Host	Comments
1890	U.S.A.	<i>Raphidia</i> sp.	Codling Moth	
1891	U.S.A.	<i>Raphidia</i> sp.	Codling Moth	
	U.S.A.	<i>Chrysopa</i> sp.	Aphids	
1904	Europe	<i>Chrysopa perla</i>	? Aphids	Or earlier
1921	Australia	<i>Chrysopa</i> sp.	Aphids	{ ? 1 importation or 2
	Australia	<i>Chrysopa</i> sp.	Mealybugs	
	Australia	<i>Ithone fusca</i>	Grass Grub	
1922	U.S.A.	<i>Chrysoperla plorabunda</i>	Aphids	
1924	England	<i>Conwentzia psociformis</i>	Aphids	
1925	U.S.A.	<i>Chrysoperla plorabunda</i>	Aphids	
	U.S.A.	<i>Chrysopa oculata</i>	Aphids	
	U.S.A.	<i>Sympherobius barberi</i>	Aphids, Mealybugs	
	U.S.A.	<i>Sympherobius californicus</i>	Aphids, Mealybugs	
	U.S.A.	<i>Sympherobius</i> sp.	Mealybugs	
	Canada	<i>Chrysopa</i> sp.	Aphids, Pine Adelgid	
1926	U.S.A.	<i>Sympherobius</i> sp.	Mealybugs	
	U.S.A.	<i>Chrysoperla plorabunda</i>	Aphids	
	U.S.A.	<i>Chrysopa oculata</i>	Aphids	
1927	Canada	<i>Chrysopa</i> sp.	Aphids, Pine Adelgid	
	Canada	<i>Chrysoperla downesi</i>	Pine Adelgid	
1928	Australia	<i>Chrysopa</i> sp.	Mealybugs	
	Australia	<i>Plesiochrysa ramburi</i>	Aphids, Mealybugs	
	U.S.A. ex Australia	<i>Plesiochrysa ramburi</i>	Aphids, Mealybugs	Colony established in U.S.A.
1932	England	<i>Hemerobius stigma</i>	Pine Adelgid	
1965	Australia	<i>Chrysopa</i> sp.	Passion Vine Hopper	
1968	U.S.A.	<i>Chrysoperla plorabunda</i>	Aphids	As <i>carnea</i>
1969	Australia	<i>Chrysopa</i> spp.	Aphids	
	Pakistan	<i>Chrysoperla carnea</i>	Aphids	
1970	U.S.A.	<i>Chrysoperla plorabunda</i>	Aphids	As <i>carnea</i>
1972	U.S.A.	<i>Chrysopa nigricornis</i>	Aphids	

Scale Insects. Hemiptera: Homoptera: Eriococcidae

Little mention has been made of predation on Scale Insects.

Tomato Fruitworm. Lepidoptera: Noctuidae: *Helicoverpa armigera conferta* Walker, 1857

Predation on this pest has been suggested.

Order NEUROPTERA

Family CONIOPTERYGIDAE

Cryptoscenea australiensis (Enderlein, 1906)

Cryptoscenea australiensis : Collyer, 1964, N.Z. J. Agric. Res. 7 (4): 558.

Cryptoscenea australiensis : Valentine, 1964, N.Z. J. Sci. Rev. 22 (2): 16.

Cryptoscenea australiensis : Valentine, 1967, N.Z. J. Sci. 10 (4): 1147.

Cryptoscenea australiensis : Collyer & van Geldermalsen, 1975, N.Z. J. Zool. 2: 128.

Cryptoscenea australiensis : Charles, 1981, N.Z. J. Zool. 8: 292.

Cryptoscenea australiensis : Charles 1989, CAB Tech. Comm. No.10: 227.

A colony of this species was discovered in 1959-60 (Kimmins & Wise 1962) and found to be predatory on Mealybugs which were later described as a new endemic species (*Trionymus wisei* Williams & de Boer, 1973). Valentine (1964) listed it as predatory on Mealybugs. The species has also been found feeding on Mites (Collyer 1964). Valentine (1967) recorded larval predation by this species mainly on eggs of Mealybugs (Pseudococcidae) and of Scale Insects (Eriococcidae) from his own observations. It was found feeding on Mealybugs on apple trees (Collyer & van Geldermalsen 1975). Charles (1981) recorded it in vineyards. Both adults and larvae are active predators of mealybugs.

Heteroconis ornata Enderlein, 1905

Heteroconis ornata : Wise, 1988, Rec. Auckland Inst. Mus. 25: 181.

Heteroconis ornata : Wise, 1991, Rec. Auckland Inst. Mus. 28: 214.

Wise (1988, 1991) recorded the occurrence of this Australian species in two separate areas of Auckland in 1988-90. This species may have the same potential as the previous one.

Family HEMEROBIIDAE

Micromus tasmaniae (Walker, 1860)

Micromus tasmaniae : Myers, 1921, N.Z. J. Agric. 23: 158.

Micromus tasmaniae : Miller, 1925, N.Z. State For. Serv. Bull. No. 2: 26.

Micromus tasmaniae : Gourlay, 1930, N.Z.D.S.I.R. Bull. No. 22: 9.

Micromus tasmaniae : Dumbleton, 1932, N.Z. J. Sci. Tech. 13 (4): 218.

Micromus tasmaniae : Clark, 1932, N.Z. J. Sci. Tech. 13 (4): 236.

Micromus tasmaniae : Miller & Clark, 1935, N.Z. J. Sci. Tech. 16: 305.

Micromus tasmaniae : Miller, 1935, Garden pests New Zealand, 34.

Micromus tasmaniae : Miller, 1944, Garden pests New Zealand (2nd. ed.), 36-37.

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Micromus tasmaniae : Walker, J.T.S., 1989, CAB Tech. Comm. No. 10: 197.
Micromus tasmaniae : Charles, 1989, CAB Tech. Comm. No. 10: 227.
Micromus tasmaniae : Farrell & Stufkens, 1990, Bull. Ent. Res. 80: 381.

This Australian species has long been established in New Zealand (Wise 1993). Myers (1921) recorded it as feeding on pest Aphids. Miller (1925) recorded it as a predator of Spruce Aphid and Dumbleton (1932) had reared it from larvae attacking Spruce Aphid. Clark (1932) and Miller & Clark (1935) recorded the species as one of three predators of Pine Adelgid, and Rawlings (1953) listed it. Miller (1935, 1944) recorded it as a predator of Mealybugs but Charles (1989) was unable to confirm this for New Zealand (only for Australia). It was recorded by Carter (1949) as a predator of Pittosporum Psyllid. Hilson (1964) recorded *Micromus tasmaniae* as feeding on Aphids and other insects on crops, and considered biological control. Valentine (1964) listed it as predatory on Aphids, Woolly Apple Aphid and Mealybugs. Valentine (1967) recorded this species on Woolly Apple Aphid, Spruce Aphid and other Aphids, Pine Adelgid, Mealybugs and the Pittosporum Psyllid, mostly from earlier records. Collyer & van Geldermalsen (1975) recorded *M. tasmaniae* as present with Mealybugs and feeding on Woolly Apple Aphid and other Aphids on apple trees; later J. T. S. Walker (1989) noted their record of this aphid predator. Charles (1981) mentioned the species as a general predator on grapevines. Early (1984) recorded it as a predator of both Aphids and Mealybugs.

Thomas (1977) had noted *Micromus tasmaniae* as common against Aphids on lucerne. Syrett & Penman dealt with this species as a predator of Aphids on lucerne and reported (1980) that it had a higher resistance to the insecticide tested than the pest Aphid. They (Syrett & Penman 1981) also recorded physiological research which indicated that low threshold temperature tolerance of *M. tasmaniae* may relate to early seasonal appearance. Subsequently, it is recorded (Cameron *et al.* 1983, Cameron & Walker 1989, Walker & Cameron 1989) as an aphid predator in lucerne crops capable of responding to early season aphid increases, as the predator best synchronised with lucerne Aphids and, perhaps, the most effective of all the aphid predators.

Cameron & Valentine (1985) noted the presence of *Micromus tasmaniae* amongst larvae of a Lepidopteran pest, the Tomato Fruitworm, but not predation, although Cameron (1989) considered it to be predatory. The species is recorded as an aphid predator on cereal crops and grasses (Farrell & Stufkens 1988, 1990, Stufkens & Farrell 1989), and as a general predator of Aphids (Thomas 1989: 57).

Drepanacra binocula (Newman, 1838)

- Drepanacra binocula* : Gourlay, 1930, N.Z.D.S.I.R. Bull. No. 22: 9.
Drepanacra binocula : Dumbleton, 1932, N.Z. J. Sci. Tech. 13 (4): 218.
Drepanacra binocula : Miller & Clark, 1935, N.Z. J. Sci. Tech. 16: 305.
Drepanacra binocular : Carter, 1949, N.Z. J. Sci. Tech. (B) 31 (2): 40, 41 (in error for *binocula*).

- Drepanacra binocula* : Rawlings, 1953, Forest Res. Notes 1 (8): 14.
Drepanacra binocula : Valentine, 1964, N.Z. Sci. Rev. 22 (2): 16.
Drepanacra binocula : Valentine, 1967, N.Z. J. Sci. 10 (4): 1148.
Drepanacra binocula : Collyer & van Geldermalsen, 1975, N.Z. J. Zool. 2: 129.
Drepanacra binocula : Harrison, 1976, New Zealand insect pests, 71.
Drepanacra binocula : Thomas, 1977, Proc. 30th. Weed & Pest Control Conf., 183.
Drepanacra binocula : Somerfield, 1984, New Zealand pest and beneficial insects, 85.
Drepanacra binocula : Walker, J.T.S., 1989, CAB Tech. Comm. No.10: 197.

This is another long established Australian species. Gourlay (1930) listed Psyllids as hosts. Dumbleton (1932) reared *Drepanacra binocula* from larvae attacking Spruce Aphid. Miller & Clark (1935) included this species as a predator of Pine Adelgid. It was recorded by Carter (1949) as the most abundant predator of Pittosporum Psyllid. Miller & Clark (1935) included this species as one of the three predators of Pine Adelgid and it was listed by Rawlings (1953). *Drepanacra binocula* is now presumed to be the species referred to by Clark (1932) as *Protobiella zelandica* (see Part III below). Valentine (1964) listed it as predatory on Aphids including Woolly Apple Aphid. *Drepanacra binocula* was mentioned by Hilson (1964) in his study of *Micromus tasmaniae*. Valentine (1967) recorded the species on Aphids including Spruce Aphid and one endemic species (*Neophyllaphis totarae* Cottier, 1953), on Pine Adelgid, the Pittosporum Triozid and a Psyllid, from earlier records and his own observations. Collyer & van Geldermalsen (1975) recorded it as predatory on Woolly Apple Aphid and other Aphids on apple trees. Harrison (1976) noted this as an important predator of Pittosporum Triozid and Somerfield (1984) also recorded it on this host. It was noted by Thomas (1977) as rare on Aphids in lucerne.

Wesmaelius subnebulosus (Stephens, 1836)

- Boriomyia maorica* : Carter, 1949, N.Z. J. Sci. Tech. (B) 31 (2): 40, 41.
Boriomyia maorica : Valentine, 1967, N.Z. J. Sci. 10 (4): 1148.

This species was first described in New Zealand as an endemic but later recognised as a common European species (Wise 1973). A specimen collected in Dunedin, N.Z., in 1920, was designated the type of *Boriomyia maorica* by Tillyard (1923).

Three larvae were recorded by Carter (1949) from field work done 1942-45 and there are two adults, in collections known to the present author, labelled as bred from larvae feeding on Pittosporum Psyllids in 1942 and 1943 by M. W. Carter. *Boriomyia maorica* was mentioned by Hilson (1964) in his study of *Micromus tasmaniae*. Valentine (1967) recorded the species predatory on Pittosporum Psyllid, from the earlier record by Carter. There are also specimens of this neuropteran collected from lucerne crops in Canterbury, South I., N.Z., in 1978, 1984 and 1985.

Psectra nakaharai New, 1988

- Symphorobius* group : Wise, 1973, N. Z. Ent. 5 (2): 183.
Psectra nakaharai : Wise, 1988, Rec Auckland Inst. Mus. 25: 182.

An Australian species considered to be associated with *Acacia* in New Zealand and not known as a predator of pests.

III. ENDEMIC NEW ZEALAND NEUROPTERA

Family BEROETHIDAE

Protobiella zelandica Tillyard, 1923

Protobiella zelandica : Gourlay, 1930, N.Z.D.S.I.R. Bull. No. 22: 9.

Protobiella zelandica : Clark, 1932, N.Z. J. Sci. Tech. 13: 236.

Protobiella zelandica : Rawlings, 1953, Forest Res. Notes 1 (8): 14.

Protobiella zelandica : Valentine, 1967, N.Z. J. Sci. 10 (4): 1147 (in error for *zelandica*).

Gourlay (1930) listed *Chermes pini* (now *Pineus laevis*) as the host for *Protobiella zelandica*, probably from the work of A. F. Clark, and Clark (1932) recorded *P. zelandica* amongst three predators of Pine Adelgid on pine. The species was subsequently listed by Rawlings (1953), and Valentine (1967) also recorded it as predatory on Pine Adelgid, from earlier records. It was mentioned as the Family Beroethidae by Zondag & Nuttall (1989).

Wise (1992) has not accepted Clark's record as there is no evidence that Clark saw Beroethid adult lacewings, no relevant specimens of the one species in New Zealand have been found in collections and the larva has still not been described. In fact, Miller & Clark (1935) also recorded three predators of Pine Adelgid but *Protobiella zelandica* was replaced by *Drepanacra binocula*, which is now taken to be a correction. Records after 1935 were based on the earlier error.

DISCUSSION

The many importations of predatory Neuropteroids to control insect pests, as shown in the records listed above (Part I), were not successful. Importation of Snakeflies (Raphidioptera) was tried only in the late 1800s and was not continued. Importations of Lacewings (Neuroptera) against Mealybugs were continued from the 1890s until the late 1920s and against Aphids until 1972. Others were to control Grass Grub in the 1920s, Pine Adelgids in the 1920s-30s, and Passion Vine Hopper in the 1960s.

Although there are records of established Neuroptera as predators of pests (Part II), mainly since the 1920s, there appears to have been a later awareness, possibly since the 1960s, of self-established (considered by Wise 1991 to be indigenous) and/or accidentally introduced species as useful predators. These are mainly species of the Family Hemerobiidae from Australia, with one from Europe, and a species of Coniopterygidae from Australia.

The one case of an endemic species recorded as a predator on insect pests (Part III) is considered to be false.

Amongst all the records of imported predatory Neuropteroids there is no mention of any effect they would have on the endemic fauna, if established. This would appear to be in contradiction to the principles of host specificity often applied rigorously to the introduction of parasites.

The successful introduction of such non-specific predators could mean the loss of native insect species, particularly of Aphids and Mealybugs. Further, such an effect on endemics could already be happening with self-introduced indigenous species or accidentally introduced species. An indication that this can occur was shown by the discovery (Kimmins & Wise 1962) of an Australian species of Coniopterygidae feeding on a colony of a then undescribed endemic species of Mealybugs. Another is the record by Valentine (1967) of an endemic species of Aphids as a host for an Australian species of Hemerobiidae.

It is suggested that introduced and imported predatory Lacewings should be considered, not as beneficial insects, but as pests in regard to the safety of the endemic insect fauna.

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